## REMARKS

### Status Summary

Claims 74-77 and 98-173 are pending in the subject application. Claims 74-77 and 98-173 presently stand rejected. Portions of the specification have also been rejected as noted below.

Claim 173 has been canceled herein. Claims 74, 103, 107, 118, 122, 133, 137, 142, 150, 157, 162, 166, and 172 have been amended. The specification has been amended. New claims 174-200 have been added. Support for the amendments and new claims can be found in the application as filed. No new matter has been added. Therefore, upon entry of this Amendment, claims 74-77, 98-172, and 174-200 will be pending in the subject application.

### Objections - Specification

The Examiner has objected to the specification.. In particular, the Examiner requests correction regarding the blanks left in some of the prior art references on pages 1, 2, and 8.

Applicants respectfully submit that the application has been amended herein to fill in the U.S. patent numbers corresponding to the application serial numbers cited on pages 1, 2, and 8 of the specification or to remove the blank in the phrase "U.S. Patent No. _______". Accordingly, applicants respectfully submit that the Examiner's objections to the disclosure have been addressed.

### Claim Rejection - 35 U.S.C. § 112, First Paragraph

Claims 98-127 and 173 have been rejected by the Examiner under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the written description requirement. More particularly, the Examiner asserts that the specification as filed does not provide support for the specifically recited carbon-dissolving materials of claims 98-112, the specifically recited carbide-forming

materials of claims 113-127, and the low melting point materials of claim 173. See Official Action dated June 22, 2006, paragraph 3.

After careful consideration of the rejection and the Examiner's comments, applicants respectfully traverse the rejection as addressed below.

Initially, applicants respectfully submit that, without acquiescing to the rejection or the Examiner's comments, claim 173 has been canceled, thus rendering the instant rejection with respect to claim 173 moot.

With respect to the rejection of claims 98-127, applicants respectfully submit that the specification as filed recites that the adhesion of nanotubes can be improved by "adhesion promoting materials such as binders, carbon-dissolving or carbide-forming metal." See Specification, page 14, lines 27-29. The subject application as filed further describes that adhesion-promoting metals include iron, cobalt, nickel, tantalum, niobium, vanadium, and hafnium. See Specification, page 15, lines 23-25.

Further, the subject application incorporates by reference, in its entirety, U.S. Patent No. 6,277,318 to Bower *et al.* (hereinafter "Bower '318"). See Specification, page 2, lines 5-8. Claim 4 of Bower '318 discloses that carbon-dissolving materials can be selected from nickel (Ni), iron (Fe), cobalt (Co), and manganese (Mn), the specific carbon-dissolving metals recited in claim 98. See Bower '318, column 4, claim 4. Claim 4 of Bower '318 further discloses that carbide-forming metals can be selected from among tantalum (Ta), niobium (Nb), vanadium (V), and hafnium (Hf), the specific carbide-forming metals recited in claim 113. See Bower '318, column 4, claim 4. These specific carbon-dissolving and carbide-forming metals are also recited in the specification of Bower '318. See Bower '318, column 2, lines 41-48. Applicants respectfully submit that the incorporation of "essential" material (*i.e.*, material necessary to support the claims) can be incorporated by reference to an issued U.S. patent or to a published U.S. patent application. See Manual of Patent Examining Procedure (hereinafter "MPEP") § 608.01(p).

Applicants respectfully submit that the instant specification has been amended herein to include the above-referenced material from Bower '318. In

particular, the specification has been amended to recite that the substrate in Bower '318 Patent is patterned with a carbide-forming material, a carbon-dissolving material or a low melting point metal. The specification has also been amended to recite that carbon-dissolving materials include Ni, Fe, Co, and Mn and that carbide-forming elements include Si, Mo, Ti, Ta, W, Nb, Zr, V, Cr, and Hf. Support for these amendments can be found in Bower '318 Patent at column 1, lines 55-61, and at column 2, lines 41-48. Applicants respectfully submit that replacement of material incorporated by reference with actual text is not new matter. See MPEP § 2163.07(b).

Thus, applicants respectfully submit that the specification as filed discloses that suitable adhesion-promoting materials include both carbide-forming and carbon-dissolving metals and, with the exception of manganese, discloses each of the specific metals recited in claims 98 and 113. Further, Bower '318, which was incorporated by reference in the present application and which issued August 21, 2001, prior to the filing date of the present application, provides teaching related to the additional specifically recited carbon-dissolving material of claim 98, *i.e.*, manganese (Mn). Bower '318 also provides teaching related to the categorization of the specific metals as carbon-dissolving or carbide-forming.

Accordingly, applicants respectfully submit that claims 98 and 113, as well as the claims depending therefrom, claims 99-112 and 114-127, comply with 35 U.S.C. § 112, second paragraph. Accordingly, applicants respectfully request that the rejection of claims 98-127 under 35 U.S.C. § 112, second paragraph, be withdrawn and that claims 98-127 be allowed at this time.

## Claim Rejections - 35 U.S.C. § 103 over the Russ '755

Claims 74, 75, and 77 have been rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 6,342,755 to Russ *et al.* (hereinafter "Russ '755"). More particularly, the Examiner contends that the differences between Russ '755 and claims 74, 75, and 77 are: i) the use of carbon nanotubes or nanowires and ii) the suspension containing both the

nanostructured material and the metal. The Examiner further contends that since Russ '755 particles are nanostructure-containing materials and include forms of carbon and oxide, the use of any known equivalent form of carbon would have been within the level of ordinary skill in the art. Finally, the Examiner contends that since Russ '755 discloses a suspension containing particles of metals such as tin and forms of carbon, it would be "*prima facie* obvious to combine two compositions each of which is taught by the prior art to be useful for the same purpose, in order to form a third composition which is to be used for the very same purpose." See Official Action dated June 22, 2006 at paragraph 5 (quoting *In re Kerkhoven*, 205 U.S.P.Q. 1069; *In re Susi*, 169 U.S.P.Q. 423; and *In re Crockett*, 126 U.S.P.Q. 186).

After careful consideration of the rejections and the contentions asserted, applicants respectfully traverse these contentions as discussed below.

Initially, applicants respectfully submit that claim 74 has been amended to recite that the emission current density of the composite layer is greater than 1 $A/cm^2$. Support for the amendment can be found in the application as filed. In particular, support can be found in the specification at page 14, lines 4-6, which recites that according to the present invention a film is formed that "can produce an emission current density greater than 1 $A/cm^2$." Support can also be found in original claim 32, which is directed to a nanotube film wherein the emission current density is larger than 1 $A/cm^2$.

Applicants further submit that to establish a *prima facie* case of obviousness, all the claim limitations must be taught or suggested by the prior art. See MPEP § 2143.03; and *In re Royka* 490 F.2d 981, 180 USPQ 580 (CCPA 1974). Further the motivation to make the claimed combination and a reasonable expectation of success must both be found in the prior art, and not based on applicants disclosure. See *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Applicants respectfully submit that Russ '755 does not teach or suggest a method of depositing a composite film using iron, lead, or cobalt particles to promote the adhesion of a nanostructured material as recited in claim 74(ii).

Further, Russ '755 does not teach any suspension for electrophoretic deposition containing a metal selected from iron, lead or cobalt. Nor does Russ '755 teach or suggest a process for depositing a composite layer wherein the composite layer has an emission current density greater than 1 $A/cm^2$. Indeed, Russ '755 does not provide any numerical emission current density data. Russ '755 merely describes emission uniformity in general terms based on the number of emission sites per centimeter. See Russ '755, column 8, lines 39-46. Thus, applicants respectfully submit that Russ '755 does not teach or suggest each and every element of claim 74.

With regard to the Examiner's contention that a suspension containing both a nanostructured material and a metal would be obvious in view of the Russ '755 disclosure of a suspension containing particles of metals such as tin and forms of carbon, applicants respectfully submit that the metal particles in Russ '755 suspension are not being used for the same purpose as the metal particles in the suspension of the presently disclosed subject matter. Russ '755 discloses that metal particles such as tin are being used as electron emitting particles. See Russ '755, column 2, lines 19-20. The other metal particles described by Russ '755 are used as "insulating" particles. In particular, Russ '755 teaches that insulating particles have a particular band gap, indicating that an "insulating" particle is selected based on electronic properties. See Russ '755, column 2, lines 24-25. Russ '755 does not suggest that the metal insulating particles or the metal emitting particles possess any adhesive properties toward the carbon-based emitting particles or that the metal particles can chemically react with the emitting particles. Instead, Russ '755 describes that the hydroxide formed from the reaction of the charging salt with water acts as a binder, and that the water content has an effect on the adhesion of the emitting particles to the conductive layer and to each other. See Russ '755, column 2, lines 52-56. Therefore, applicants respectfully submit that the metal particles of Russ '755 and the metal particles of the currently disclosed subject matter are not being used for the same purpose and that, therefore, a suspension containing metal particles to

promote the adhesion of carbon nanotubes or nanowires is not *prima facie* obvious.

Further, applicants respectfully disagree with the Examiner's contention that carbon nanotubes or nanowires are equivalent forms of carbon to those recited in Russ '755. While generally disclosing that emitting particles can include "forms of carbon," Russ '755 specifically recites the use of "graphite carbon, diamond, and amorphous carbon" as emitting particles. See Russ '755, column 2, lines 18-20. Carbon nanotubes and nanowires comprise a fullerene allotrope of carbon and have unique properties compared with other forms of carbon. Some of the unique aspects of carbon nanotubes and the difficulties related to the adhesion of carbon nanotube films are described in Bower '318, which as noted hereinabove, was incorporated by reference in its entirety into the subject application. Bower '318 recites with respect to carbon nanotubes:

> These forms of nanotubes do not lend themselves to convenient preparation of robust adherent nanotube thin film structures. The difficulty in preparing an adherent film of nanotubes is believed to be due to the perfect structure associated with carbon nanotubes, which contain essentially no dangling bonds and few defect sites.

See Bower '318, column 1, lines 24-31.

Thus, applicants submit that one of skill in the art would not have a reasonable expectation of success that the teachings of Russ '755 would apply to the electrophoretic deposition of carbon nanotubes or nanowires in the absence of their explicit disclosure. Rather, applicants submit that the motivation to use the specific metals recited in claim 74 comes not from the teachings of Russ '755, but from the applicants' disclosure that the adhesion of nanotubes can be improved by the use of adhesion promoting materials and the specific recitation of iron, lead and cobalt as adhesion-promoting metals. See Specification, page 14, lines 27-29, and page 15, lines 10-11 and 23-25. Therefore, applicants respectfully submit that the present rejection of claim 74 is improper.

Claims 75 and 77 depend from claim 74 and, thus, include all of the limitations of claim 74. Therefore, applicants respectfully submit that Russ '755 does not teach or suggest all of the elements of claims 75 and 77.

Accordingly, applicants respectfully submit that claims 74, 75 and 77 are patentable over Russ '755. Applicants respectfully request that the rejection of claims 74, 75, and 77 under 35 U.S.C. § 103(a) over Russ '755 be withdrawn, and further request that claims 74, 75, and 77 be allowed at this time.

Claim Rejections - 35 U.S.C. § 103 over Russ '755 and Choi '497

Claim 76 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Russ '755 as applied to claims 74, 75, and 77 and further in view of U.S. Patent No. 6,616,497 to Choi *et al.* (hereinafter "Choi '497"). The Examiner alleges that the difference between claim 76 and Russ '755 is the provision of shortening the length of the carbon nanotubes prior to their introduction into the suspension. The Examiner contends that Choi '497 discloses shortening carbon nanotubes at column 4, lines 13-17 and that, therefore, it would have been obvious to one of skill in the art at the time the invention was made to modify the teachings of Russ '755 as shown by Choi '497. See Official Action dated June 22, 2006, paragraph 6.

After careful consideration of the rejections and the contentions asserted, applicants respectfully traverse these contentions as discussed below.

Initially, applicants respectfully submit that Choi '497 at column 4, lines 13-17 appears to disclose that carbon nanotubes can be reacted with a strong acid "to remove impurities therefrom." Choi '497 further suggests that the nanotubes can be "cut to appropriate lengths." See Choi '497, column 4, lines 17-18. However, it does not appear that Choi '497 teaches or suggests that it is the acid treatment or any other chemical treatment or reaction that shortens the nanotubes. Rather, the shortening process described by Choi '497 appears to be a mechanical cutting process. Thus, applicants respectfully submit that Choi '497 does not teach or suggest shortening carbon nanotubes by chemical reaction prior to their introduction into a suspension, as recited in claim 76.

Applicants further respectfully submit that it appears that Choi '497 is being relied on for describing methods of shortening or otherwise preparing carbon nanotubes prior to their electrophoretic deposition. Choi '497 does not cure the deficiencies of Russ '755 with respect to claim 74. Moreover, applicants submit that one of skill in the art would not be motivated to combine or have an expectation of success in combining the teachings of Choi '497 and Russ '755, because Russ '755 does not teach or disclose the electrophoretic depositon of carbon nanotubes.

Accordingly, applicants respectfully submit that Russ '755 and Choi '497, either alone or in combination, do not teach or suggest each and every element of claim 76. Applicants respectfully request that the present rejection of claim 76 be withdrawn, and that claim 76 be allowed at this time.

<u>Claim Rejections - 35 U.S.C. § 103 over Bower '579 in view of Russ '755</u>

Claims 74, 75, 77, 157, 159-168, and 170 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over published European Patent Application EP 989,579 to Bower *et al.* (hereinafter "Bower '579") and further in view of Russ '755. <u>See</u> Official Action dated June 22, 2006, paragraphs 7 and 15. The Examiner alleges that Bower '579 discloses the electrophoretic deposition of a nanotube film from a solution containing nanotubes, solvents, binders, and, optionally, conductive particles of elemental metals, followed by annealing the deposited materials in air, vacuum or inert atmosphere. The Examiner alleges that the difference between Bower '579 and claims 74, 75, and 77 is the provision of the recited metals and of a charger in the solution. With regard to the recited metals, the Examiner alleges that the selection of any known equivalent metals to promote adhesion would have been within the level of ordinary skill in the art. With respect to the charger, the Examiner alleges that the use of a charger would have been an obvious modification due to the teachings of Russ '755. <u>See</u> Official Action dated June 22, 2006, paragraph 7. Finally, regarding claims 159-168 and 170, the Examiner alleges that Bower '579

discloses pre-coating the substrate at paragraphs [0027] and [0023]. See Official Action dated June 22, 2006, paragraph 15.

After careful consideration of the rejection and the Examiner's comments, applicants respectfully traverse the rejection and offer the following comments.

Initially, applicants respectfully submit that claims 74 and 157 have been amended herein to recite that the emission current density of the composite layer is greater than 1 $A/cm^2$. Support for the amendments can be found in the specification as filed at page 14, lines 4-6, which recites that, according to the present invention, a film is formed that "produces an emission current density greater than 1 $A/cm^2$." Support can also be found in original claim 32, which is directed to a nanotube film wherein the emission current density is larger than 1 $A/cm^2$. Claim 157 has also been amended to remove cadmium, zinc and bismuth from the groups of adhesion–promoting metals in step (iii).

With regard to claim 74, applicants respectfully submit that neither Russ '755 nor Bower '579 teach or suggest a method of depositing a composite film using iron, lead, or cobalt particles in a suspension of nanostructured material to promote the adhesion of the nanostructured material as recited in claim 74(ii). As discussed previously hereinabove, Russ '755 does not teach a suspension for electrophoretic deposition specifically containing iron, lead or cobalt. Moreover, as discussed hereinabove, Russ '755 is not directed to methods of depositing carbon nanotubes or equivalent forms of carbon particles. Also, while Bower '579 notes that a solution containing nanotube powders for deposition onto a substrate can contain conductive particles, Bower '579 specifically describes these particles as being low melting solder materials including Sn, In, Sn-In, Sn-Bi, and Pb-Sn. See Bower '579, paragraph [0028]. Thus, Bower '579 does not teach or suggest the use of carbon-reactive metals such as the carbon-dissolving elements iron and cobalt as particles to promote adhesion when the particles are mixed in a suspension of carbon nanotubes, nor does it teach that a suspension comprising carbon nanotubes or nanowires and small particles selected from iron, lead and cobalt can be co-deposited on a substrate to form a composite layer, the composite layer having an intimate mix of the carbon nanotubes and

the small particles. Based upon the disclosure in Bower '579, applicants submit that it would not be assumed that all metals were equivalent.

Further, with regard to both claim 74 and claim 157, applicants respectfully submit that neither Russ '755 nor Bower '579 describe a process for making a layer comprising carbon nanotubes or nanowires wherein the emission current density of the layer is greater than 1 $A/cm^2$. As described hereinabove, Russ '755 does not provide any numerical emission density data for a deposited film. At best, Bower '579 describes a threshold field of 2.8 V/μm to produce an emission current density of 10 $mA/cm^2$. See the '579 application, column 14, lines 25-27.

Accordingly, applicants respectfully submit that Bower '579 and Russ '755, either alone or in combination, do not teach or disclose each and every element of claims 74 and 157. Therefore, applicants respectfully request that the rejection of claims 74 and 157 under 35 U.S.C. § 103(a) over Bower '579 and Russ '755 be withdrawn and also request that claims 74 and 157 be allowed at this time.

As each of claims 75, 77, 159-164, 166-168, and 170 depend from either claim 74 or claim 157, these dependent claims each contain all of the elements of either claim 74 or claim 157. Thus, applicants submit that claims 75, 77, 159-164, 166-168 and 170 are patentable over the combination of Bower '579 and Russ '755. Thus, applicants respectfully request that the rejection of claims 75, 77, 159-164, 166-168 and 170 under 35 U.S.C. § 103(a) over Bower '579 and Russ '755 be withdrawn, and request that claims 75, 77, 159-164, 166-168 and 170 be allowed at this time.

Claim Rejections - 35 U.S.C. § 103 over Bower '579 in view of Russ '755 and further in view of Choi '497

Claims 76 and 158 have been rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Bower '579 in view of Russ '755 and further in view of Choi '497. See Official Action dated June 22, 2006, paragraphs 8 and 16. In particular, the Examiner contends that Choi '497 teaches shortening

carbon nanotubes prior to their electrophoretic deposition, and that, therefore, in view of the teachings of Bower '579 and Russ '755, the subject matter of claims 76 and 158 would have been obvious.

As described hereinabove, applicants respectfully submit that Choi '497 does not disclose or suggest that carbon nanotubes be shortened using a chemical reaction, as recited in claim 76. Applicants further respectfully submit that it appears that Choi '497 is being relied on for describing the shortening of carbon nanotubes prior to their electrophoretic deposition. Choi '497 does not cure the deficiencies of Bower '579 and Russ '755 with respect to claims 74 and 157.

Accordingly, applicants respectfully submit that the '579 application, Russ '755 and Choi '497, either alone or in combination, do not teach or suggest each and every element of claims 76 and 158. Applicants respectfully request that the present rejection of claims 76 and 158 be withdrawn, and that claims 76 and 158 be allowed at this time.

Claim Rejections - 35 U.S.C. § 103 over Bower '579 in view of Russ '755, Shiue '935, and/or DeJaeger '117

Claims 128, 130-140, 142-145, 147-155, and 169 have been rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Bower '579 in view of Russ '755, U.S. Patent No. 6,462,935 to Shiue '935 *et al.* (hereinafter "Shiue '935") and/or U.S. Patent No. 5,296,117 to De Jaeger *et al.* (hereinafter "De Jaeger '117"). See Official Action dated June 22, 2006, paragraphs 9, 12, and 17. More specifically, the Examiner alleges that the Bower '579 discloses the use of binders at paragraph [0028]. The Examiner also alleges that Shiue '935 teaches a coating paste of nanoparticles and binders, including polyvinylidene fluoride. The Examiner further alleges that De Jaeger '117 discloses a process of electrophoretically depositing particles with binders in addition to a charger. Thus, the Examiner concludes that it would be obvious to have modified Bower '579 as suggested by Shiue '935 or De Jaeger '117 to fix particles with any known organic resin binder. Further, with respect to the two-

step annealing process of claim 137 and, presumably, of claims 142-145 and 147-155, the Examiner contends that Bower '579 discloses a two-step annealing process at paragraph [0028] and [0029]. See Official Action dated June 22, 2006, paragraph 9.

After careful consideration of the rejections and the contentions asserted, applicants respectfully traverse the rejections and submit the following remarks.

Initially, applicants respectfully submit that the nanoparticles of Shiue '935 are ferrites, *i.e.*, hydrated iron compounds having the chemical formula $Fe_xO_yH_z$, wherein x is 1-3, y is 0-4, and z is 0-1.03. See Shiue '935, column 3, lines 50-52. Thus, Shiue '935 relates to the deposition of inorganic particles, not carbon-based nanoparticles, or more particularly, carbon nanotubes, as in the current claims. Shiue '935 does not suggest that binders such as poly(vinyl butyral-co-vinyl alcohol-co-vinyl acetate) or poly(vinylidene fluoride) could be used as binders for organic (i.e., carbon-based) particles. Further, while Shiue '935 discloses that binders including poly(vinylidene fluoride) can be used in coating methods as part of a coating paste (see Shiue '935, column 6, lines 64 to column 7, line 1), Shiue '935 does not specifically provide motivation for using such a binder in a suspension as part of an electrophoretic deposition method.

Applicants respectfully submit that De Jaeger '117 relates to the use of organic resin binders as part of a process for fixing phosphor particles. As with the particles of Shiue '935, the phosphor particles described by De Jaeger '117 are inorganic. See De Jaeger '117, column 8, lines 17-52. Thus, De Jaeger '117 does not teach or suggest the use of organic resin binders in the electrophoretic deposition of organic particles, or more particularly of carbon nanotubes, as recited in claim 128(i). Additionally, as noted in the previous Amendment, filed in the Examiner on April 4, 2006, De Jaeger '117 does not specifically teach or suggest the use of poly(vinyl butyral-co-vinyl alcohol-co-vinyl acetate) or poly(vinylidene fluoride) binders as recited in claims 128(i), 155, and 169.

Thus, applicants respectfully submit that there is no motivation to combine the teachings of Bower '579, Russ '755, Shiue '935 and/or De Jaeger '117. That the references could be combined or that it would be within the capabilities of

one of skill in the art to combine aspects of the claimed subject matter that were individually known does not render the combination *prima facie* obvious. See *In re Mills*, 916 F2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990); and *Ex parte Levengood*, 28 USPQ2d 1300 (Bd. Pat. App. & Inter. 1993). See also MPEP § 2143.01. Applicants respectfully submit that the present rejection, at best, appears to rely on an improper "obvious to try" rationale.

Accordingly, applicants believe that claims 128, 155, and 169 which specifically recite the use of a binder material selected from poly(vinyl butyral-co-vinyl alcohol-co-vinyl acetate) and poly(vinylidene fluoride), have been distinguished from the combination of the '579 application, Russ '755, and Shiue '935 and/or De Jaeger '117. Claims 130-140 depend from claim 128 and, therefore, also include the element of using a binder material selected from poly(vinyl butyral-co-vinyl alcohol-co-vinyl acetate) and poly(vinylidene fluoride). Thus, applicants further believe that dependent claims 130-140 are patentable. Applicants respectfully request that the present rejection of claims 128, 130-140, 155, and 169 be withdrawn and that claims 128, 130-140, 155, and 169 be allowed at this time.

With respect to claims 137, 142-145, and 147-155, applicants respectfully submit that claims 137 and 142 have been amended herein to clarify that the material being heated to the first and second temperatures is the same material (*i.e.*, the coated substrate). Applicants respectfully submit that this amended wording is in keeping with the disclosure in the specification. See Specification, page 13, third full sentence. Accordingly, the two step annealing process of claims 137 and 142(vi) recites "heating the coated substrate to a first temperature for a first selected period of time, then heating the coated substrate to a second temperature for a second period of time." Applicants further note that claim 143 recites that the first temperature is 100-1200°C, the first period of time is approximately one hour, the second temperature is 800°C, and the second period of time is approximately two hours.

With regard to the disclosure of Bower '579, applicants respectfully submit that the paragraphs cited by the Examiner, paragraphs [0028] and [0027], do not

teach or suggest a two-step annealing process such as recited in claims 137 and 142 or a two-step annealing process including the temperature ranges and time periods recited in claim 143. In particular, paragraph [0028] of Bower '579 recites that "annealing in either air, vacuum or inert atmosphere, *e.g.*, at a temperature of about 150 to 250°C is then typically performed to drive out the solvent and activate the binder." Paragraph [0028] does not suggest or provide any motivation for using a two-step annealing process involving heating to a first and a second temperature sequentially. Paragraph [0027] of Bower '579 recites that it is possible to coat the substrate with a low melting point material and that "subsequent heating" induces a reaction of the nanotubes and the carbon-reactive or carbide-forming elements or induces melting of the low melting point material, such that the nanotubes become anchored to the substrate. Only the "subsequent heating" appears to be subsequent to the coating of the substrate. Thus, paragraph [0027] also appears to relate to a one-step annealing process and does not specifically recite that the coated substrate is heated to two consecutive temperatures.

Accordingly, applicants submit that the two-step annealing process of claims 137, 142, and 143 is not disclosed or suggested by Bower '579, Russ '755, Shiue '935 or De Jaeger '117, either alone or in combination. Applicants respectfully request that the present rejection of claims 137, 142, and 143 be withdrawn and that claims 137, 142, and 143 be allowed at this time.

Applicants further submit that claims 144, 145, and 147-155 depend from claim 142, and note that "if an independent claim is nonobvious under 35 U.S.C. § 103, then any claim depending therefrom is nonobvious." See MPEP § 2143.03; and *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir.1988). Thus, applicants, respectfully request that the present rejection of claims 144, 145, and 147-155 be withdrawn and that claims 144, 145, and 147-155 be allowed at this time.

Claim Rejections - 35 U.S.C. § 103 over Bower '579 in view of Russ '755, Shiue '935, and/or De Jaeger '117, further in view of Choi '497

Claims 129 and 146 have been rejected under 35 U.S.C. § 103(a) over Bower '579in view of Russ '755, Shiue '935 and/or De Jaeger '117, further in view of Choi '497. See Official Action dated June 22, 2006, paragraphs 10 and 13. Particularly, the Examiner contends that Choi '497 provides the added limitation of shortening carbon nanotubes prior to their introduction into a suspension. See Official Action dated June 22, 2006, paragraph 10.

Claims 129 and 146 depend from claims 128 and 142, respectively. Thus, claims 129 and 146 contain each and every element of either claim 128 or claim 142. Applicants respectfully submit that it appears that Choi '497 is being relied on for describing the shortening of carbon nanotubes prior to their electrophoretic deposition. Choi '497 does not cure the deficiencies of Bower '579, Russ '755, Shiue '935, and/or De Jaeger '117 with respect to claims 128 and 142.

Accordingly, applicants respectfully submit that Bower '579, Russ '755 Shiue '935, De Jaeger '117, and Choi '497, either alone or in combination, do not teach or suggest each and every element of claims 129 and 146. Applicants respectfully request that the present rejection of claims 129 and 146 under 35 U.S.C. § 103 be withdrawn, and that claims 129 and 146 be allowed at this time.

Claim Rejections - 35 U.S.C. § 103 over Bower '579 in view of Russ '755, Shiue '935, and/or DeJaeger, further in view of Friedman '456 or Nemelka '381

Claims 141, 156, 171 and 172 have been rejected under 35 U.S.C. § 103(a) over Bower '579 in view of Russ '755, Shiue '935 and/or De Jaeger '117, further in view of U.S. Patent No. 5,795,456 to Friedman et al. (hereinafter "Friedman '456") or U.S. Patent No. 6,319,381 to Nemelka '381 (hereinafter "Nemelka '381 '381"). See Official Action dated June 22, 2006 paragraphs 11, 14, 18, and 19. The Examiner alleges that the difference between Bower '579, Russ '755, Shiue '935, and De Jaeger '117 and the subject matter of claims 141, 156, and 171 is the provision of a masking step. The Examiner alleges that both

Friedman '456 and Nemelka '381 disclose the use of a masking step relating to the electrophoretic deposition of particles. See Official Action dated June 22, 2006, paragraphs 11, 14 and 18.

With respect to claim 172 and the subject matter of dimethyl formamide (DMF), the Examiner additionally alleges that Friedman '456 discloses the use of an organic based solvent system or water as a liquid medium in the electrophoretic deposition of particles at the paragraph crossing columns 10 and 11. The Examiner contends that Nemelka '381 also discloses the use of an organic based solvent at column 3, lines 62-65. Thus, the Examiner contends that based upon the teachings of Friedman '456 and Nemelka '381, the selection of any known organic solvent based system in the electrophoretic deposition of particles would have been within the level of ordinary skill in the art. See Official Action dated June 22, 2006, paragraph 19.

Initially, applicants respectfully submit that claim 172 has been amended herein to recite that the emission current density of the composite layer is greater than 1 $A/cm^2$. Support for the amendment can be found in the specification as filed at page 14, lines 4-6, which recites that, according to the present invention, a film is formed that "produces an emission current density greater than 1 $A/cm^2$." Support can also be found in original claim 32, which is directed to a nanotube film wherein the emission current density is larger than 1 $A/cm^2$.

Further, applicants respectfully submit that neither Nemelka '381 nor Friedman '456 relate to carbon nanotube deposition. In particular, Nemelka '381 relates to the deposition of inorganic phosphor-comprising materials. See Nemelka '381, column 3, line 65 to column 4, line 2. Friedman '456 is related to the deposition of catalysts for catalytic converters, wherein the catalysts are non-organic particles, such as, metals or metal oxides. Neither Friedman '456 nor Nemelka '381 disclose a particle size. Thus, applicants respectfully submit that Friedman '456 and Nemelka '381 do not teach or suggest the use of a masking technique in the deposition of carbon nanoparticles. Therefore, applicants respectfully submit that one of skill in the art would not have been motivated to combine the masking step of Friedman '456 and Nemelka '381 with the

teachings of Bower '579, Russ '755, Shiue '935 and/or De Jaeger '117 to arrive at the subject matter of claims 141, 156, or 171.

Assuming, *arguendo*, that Friedman '456 and Nemelka '381 would suggest the use of a masking technique as part of the currently claimed methods of electrophoretic deposition of carbon nanoparticles, applicants respectfully submit that claims 141, 156, and 171 depend from claims 128, 142, and 157, respectively. Applicants believe that Friedman '456 and Nemelka '381 are being relied on for their teachings related to masking techniques. Friedman '456 and Nemelka '381 do not cure the deficiencies of the Bower '579, Russ '755, Shiue '935, and/or De Jaeger '117 with respect to claims 128 and 142 or the deficiencies of Bower '579 and Russ '755 with respect to claim 157.

Accordingly, applicants respectfully submit that the Bower '579, Russ '755 Shiue '935, De Jaeger '117, Friedman '456 and Nemelka '381, either alone or in combination, do not teach or suggest each and every element of claims 141, 156, and 171. Applicants respectfully request that the present rejection of claims 141, 156, and 171 under 35 U.S.C. § 103 be withdrawn, and that claims 141, 156, and 171 be allowed at this time.

With regard to the use of DMF as the solvent in claim 172 and to the Examiner's remarks concerning the use of organic solvents in Friedman '456 and Nemelka '381, applicants respectfully submit that the organic solvents disclosed in Nemelka '381 and Friedman '456 are all organic alcohols. For example, Friedman '456 recites "an organic solvent based system, such as for example, an organic alcohol. See Friedman '456, column 11, lines 4-5. Nemelka '381 recites "a nonaqueous liquid, such as isopropyl alcohol." See Nemelka '381, column 3, lines 62-63. Neither Nemelka '381 nor Friedman '456 teach or suggest the use of any non-protic organic solvent, much less the use of DMF, specifically.

Conversely, the present application does specifically describe the use of DMF as a solvent for the electrophoretic deposition of carbon nanotubes. Further, the present application provides that a more concentrated suspension of carbon nanotubes can be prepared using DMF than using an organic alcohol. For example, the present application describes that a 0.4-0.5 mg/mL stable

suspension of single-walled carbon nanotubes can be prepared in DMF. In methanol, the concentration of single-walled carbon nanotubes in a stable suspension is only 0.01 mg/mL. See Specification, page 10, last full paragraph. Control of the nanotube concentration can be advantageous. As described in the subject application, the concentration of the nanoparticles in solution can affect many factors related to the deposition process, such as the rate of deposition and the structure and morphology of the coating. See Specification, page 11, lines 27-29.

Accordingly, applicants respectfully submit that the use of DMF as a solvent for the electrophoretic deposition of a suspension comprising carbon nanotubes is not taught or suggested by Bower '579, Russ '755, Shiue '935, De Jaeger '117, Nemelka '381, and Friedman '456, either alone or in combination. In addition, applicants respectfully submit that none of the cited references teach or suggest a method of depositing a composite layer of carbon nanotubes and an adhesion promoting material wherein the emission current density of the composite layer is greater than 1 $A/cm^2$.

Applicants respectfully request that the present rejection of claim 172 in view of Bower '579, Russ '755, Shiue '935, and/or De Jaeger '117, and further in view of Friedman '456 and Nemelka '381 be withdrawn, and request that claim 172 be allowed at this time.

## New Claims

New claims 174-200 have been added by the present amendment. No new subject matter has been added.

New claim 174 recites the method of claim 98, wherein the emission current density of the composite layer is greater than 1 $A/cm^2$. New claim 175 recites the method of claim 113, wherein the emission current density of the composite layer is greater than 1 $A/cm^2$. New claim 176 recites the method of claim 128, wherein the emission current density of the composite layer is greater than 1 $A/cm^2$. New claim 177 recites the method of claim 142, wherein the emission current density of the layer is greater than 1 $A/cm^2$.

Support for each of new claims 174-177 can be found in the specification as filed, for example, at page 14, lines 5-6, which recites that according to the present invention a film is formed that "can produce an emission current density greater than 1 A/cm$^2$." Support can also be found in original claim 32, which is directed to a film formed by the method of claim 1, upon which the present method claims are based, wherein the emission current density is larger than 1 A/cm$^2$.

New claim 178 recites the method of claim 74, wherein the composite layer has a threshold field of less than 1.5 V/micrometer. New claim 179 recites the method of claim 178 wherein the threshold field is 1.4 V/micrometer. Support for new claim 178 can be found in the specification as filed, for example, at page 14, lines 4-5, which recites a threshold field for emission of less than 1.5 volts/micrometer. Support for new claim 178 can also be found in original claim 31. Support for new claim 179 can be found in the Table on page 13, second column, bottom row, which recites a threshold field for an electrophoretically deposited (i.e., an EPD) single-wall nanotube (SWNT) film of 1.4 V/micrometer.

New claim 180 recites the method of claim 74, wherein the composite layer produces a total emission current greater than 10 mA over a 6 mm$^2$ area. Support for new claim 180 can be found in the specification as filed, for example, at page 14, lines 6-7. Support can also be found in original claim 33.

New claim 181 recites the method of claim 74, wherein the composite layer produces a pulsed emission current having a pulse frequency higher than 10 KHz. New claim 182 recites the method of claim 181, wherein the pulse frequency is higher than 100 KHz. Support for new claims 181 and 182 can be found in the specification as filed, for example, at page 14, lines 7-9. Support can also be found in original claims 38 and 39.

New claim 183 recites the method of claim 74, wherein the composite layer has a total pulsed current over a 6 mm$^2$ area higher than 10 mA at an electrical field of between 10 and 12 V/micrometer. New claim 184 recites the method of claim 74, wherein the composite layer produces a stable pulsed current, further wherein the stable pulsed current is higher than 10 mA over a 6

$mm^2$ area for at least 1,000 pulses. New claim 185 recites the method of claim 184 wherein the stable pulsed current is higher than 10 mA over a 6 $mm^2$ area for at least 10,000 pulses. Support for new claims 183-185 can be found in the specification as filed, for example, at page 14, lines 9-14. Support can also be found in original claims 40 and 41.

New claim 186 recites a method of depositing a composite film wherein a nanostructured material and small particles selected from the group consisting of iron, lead, and cobalt are deposited onto a substrate to form a composite layer wherein the composite layer (a) comprises an intimate mix of carbon nanotubes and the small particles; (b) produces an emission current density greater than 1 $A/cm^2$; (c) has a threshold field for emission of less than 1.5 V/micrometer; and (d) produces a total emission current greater than 10 mA over a 6 $mm^2$ area, a pulsed emission current having a pulse frequency higher than 100 kHz, and a total pulsed current measured over a 6 $mm^2$ area of greater than 10 mA at between 10 and 12 V/micrometer for at least 1,000 pulses. Support for new claim 186 can be found in original claim 1, as well as in original claim 2, which recites that the nanostructure-containing material can be selected from nanotubes and nanowires. Support for the addition of adhesion promoting materials can be found in the specification at page 14, line 27 to page 15, line 2. Support for the deposition of a composite layer can be found in the specification at page 16, lines 14-23. Support for the addition of iron, lead or cobalt particles to the suspension can be found in the specification at page 15, lines 10-11. Support for iron, lead and cobalt being adhesion-promoting metals can be found in the specification at page 15, lines 22-24. Further support for new claim 186 can be found in the specification as filed at page 15, lines 10-16, which recites that metal particles and nanostructures "form a coating with an intimate mixing of the metal particles and the nanostructures." Support can also be found in the specification at page 14, lines 4-14, which recites the threshold field for emission, the total emission current, the pulsed emission current and the total pulsed emission current recited new claim 186. Additional support can be found in original claims 31-33, 39, and 40.

New claim 187 recites the method of claim 186, wherein the total pulsed current is over 10 mA for at least 10,000 pulses. Support for claim 187 can be found, for example, in original claim 41 and in the specification as filed at page 14, lines 12-14.

New claim 188 recites a method of depositing a multilayer coating onto a substrate. Support for new claim 188 can be found, for example, in the specification as filed at page 16, line 14 to page 17, line 3, which recites a method of forming a composite layer comprising a nanostructured material and at least one other material, such as a polymer or metal particles, that "multiple baths can be used to produce a multilayered electrophoretic deposition," and that electrophoresis is carried out in each bath sequentially.

New claim 189 recites the method of claim 188 further comprising annealing the substrate following the deposition of the multilayer coating. New claim 190 recites the method of claim 189, wherein the annealing comprises a two-step anneal. New claim 191 recites the method of claim 188 wherein the emission current density of the multilayer coating is greater than 1 $A/cm^2$.

Support for new claims 189-191 can be found in the specification as filed. In particular, for example, support for new claim 189 can be found in the specification at page 13, line 1, which recites that "the coated substrate may be annealed." Support for new claim 190 can be found at page 13, lines 4-7, which recites an annealing process wherein the substrate is heated to a first temperature (i.e., 100-1200°C) for a first period of time (i.e., one hour) and then to a second temperature (i.e., 800°C) for a second period of time (i.e., two hours). Support for new claim 191 can be found in the specification at page 14, lines 5-6.

New claim 192 recites a method of depositing a carbon nanotube film having a stable pulsed current higher than 10 mA over a 6 $mm^2$ area for at least 1,000 pulses, the method comprising: (i) forming a suspension containing at least the carbon nanotubes and an adhesion promoting material comprising one of a carbon-dissolving and a carbide-forming material; (ii) selectively adding a charger to the liquid medium; (iii) immersing electrodes into the suspension,

wherein at least one of the electrodes comprises the substrate; and (iv) applying a direct or alternating current to the immersed electrodes to create an electrical field between the electrodes, wherein the carbon nanotubes and the adhesion promoting material co-deposit on the substrate forming a composite film having an intimate mix of carbon nanotubes and the adhesion-promoting material. New claim 193 recites the method of claim 192, wherein the composite film has a stable pulsed current higher than 10 mA over a 6 $mm^2$ area for at least 10,000 pulses.

Support for new claims 192 and 193 can be found, for example, in the specification as filed at page 14, lines 12-14. Support can also be found in the specification at page 14, lines 27-29, which recites that the incorporation of adhesion promoting materials such as carbon-dissolving or carbide-forming metal improves the adhesion of nanotubes. Support can be found in the specification as filed at page 15, lines 10-16, which recites that metal particles and nanostructures "form a coating with an intimate mixing of the metal particles and the nanostructures." Further support can be found at page 16, lines 14-23, which recites a method of electrophoretically depositing a composite layer of nanostructured materials and metal particles. Finally, support can be found in original claims 40 and 41.

New claim 194 recites a method of depositing a carbon nanotube film that displays 3% or less emission current decay after 10 hours, the method comprising: (i) forming a suspension containing at least the carbon nanotubes and an adhesion promoting material comprising one of a carbon-dissolving and a carbide-forming material; (ii) selectively adding a charger to the liquid medium; (iii) immersing electrodes into the suspension, wherein at least one of the electrodes comprises the substrate; and (iv) applying a direct or alternating current to the immersed electrodes to create an electrical field between the electrodes, wherein the carbon nanotubes and the adhesion promoting material co-deposit on the substrate forming a composite film having an intimate mix of carbon nanotubes and the adhesion-promoting material.

Support for new claim 194 can be found in the specification as filed. In particular, for example, support can be found in the Table on page 13, fourth column, bottom row, which recites that for an EPD SWNT film, the emission current decay after 10 hours was 3%. Additional support can be found in original claim 36, which recites that the decay of the total emission current is less than 3% over 10 hours. Support can also be found in the specification at page 14, lines 27-29, which recites that the incorporation of adhesion promoting materials such as carbon-dissolving or carbide-forming metal improves the adhesion of nanotubes. Support can be found in the specification as filed at page 15, lines 10-16, which recites that metal particles and nanostructures "form a coating with an intimate mixing of the metal particles and the nanostructures." Support can further be found at page 16, lines 14-23, which recites a method of electrophoretically depositing a composite layer of nanostructured materials and metal particles using a suspension of nanostructured material and at least one other component, adding a charger to the suspension, adding electrodes to the suspension, and applying a direct or alternating current.

New claim 195 recites a method of depositing a composite film comprising a carbon nanotube material onto a conducting substrate, the method comprising: (i) forming a liquid suspension comprising carbon nanotubes, particles of adhesion-promoting material, and a charger, wherein the concentration of nanotube is 0.1 – 1.0 mg/mL; (ii) immersing electrodes into the suspension, wherein one of the electrodes comprises the substrate; (iii) applying an electric field in the range of 0.1-1000 V/cm wherein the nanotubes and adhesion-promoting material co-deposit on the substrate; and (iv) annealing the substrate using a two-step anneal.

Support for new claim 195 can be found, for example, in the specification at page 16, lines 14-23, which recites a method of electrophoretically depositing a composite layer of nanostructured materials and metal particles using a suspension of nanostructured material and at least one other component, adding a charger to the suspension, adding electrodes to the suspension, and applying a direct or alternating current. Support can also be found in the specification at

page 14, lines 27-29, which recites that the incorporation of adhesion promoting materials such as carbon-dissolving or carbide-forming metal improves the adhesion of nanotubes. Support for a nanotube suspension having a concentration of 0.1-1.0 mg/mL can be found in original claim 17. Support for applying an electric field in the range of 0.1 – 1000 V/cm can be found in the specification at page 11, lines 14-15, and in original claim 19. Support for the annealing conditions can be found in the specification at page 13, lines 4-6.

New claim 196 recites a method of depositing a composite film onto one conducting surface of a substrate having at least two electrically insulated conducting surfaces, wherein one of the steps comprises applying a small bias electrical field on one of the conducting surfaces, surface B, to prevent deposition of the carbon nanotubes and particles of an adhesion-promoting material selected from carbon-dissolving and carbide-forming material thereon.

Support for new claim 196 can be found, for example, in the specification at page 18, lines 3-20, and in Figures 6A-6C, which describe a method of electrophoretically depositing a nanotube-containing layer onto one insulated conducting surface (i.e., 610) of a substrate, but not onto another insulated conducting surface (i.e., 630), by applying a bias voltage to the surface on which no deposition is desired. Support can also be found in the specification at page 16, lines 14-23, which recites a method of electrophoretically depositing a composite layer of nanostructured materials and metal particles using a suspension of nanostructured material and at least one other component, adding a charger to the suspension, adding electrodes to the suspension, and applying a direct or alternating current. Further support can be found in the specification at page 14, lines 27-29, which recites that the incorporation of adhesion promoting materials such as carbon-dissolving or carbide-forming metal improves the adhesion of nanotubes. Support for applying an electric field in the range of 0.1 – 1000 V/cm can be found in the specification at page 11, lines 14-15, and in original claim 19.

New claim 197 recites the method of claim 196, wherein surface B is covered by a layer of photoresist. Support for new claim 197 can be found, for

example, in Figure 6B and in the description of Figures 6A and 6B in the specification at page 18, lines 3-9.

New claim 198 recites the method of claim 196, further comprising annealing the coated substrate to form a film on surface A, wherein the emission current density of the film is greater than 1 A/cm$^2$. Support for new claim 198 can be found, for example, in the specification at page 14, lines 5-6, which describes an emission current density of greater than 1 A/cm$^2$; and at page 13, line 1, which recites that the coated substrate may be annealed.

New claim 199 recites the method of claim 76, wherein the shortening of the carbon nanotubes by chemical reaction involves etching the nanotubes in a solution of $H_2SO_4$ and $HNO_3$ for between 10 and 24 hours while exposing the nanotubes to ultrasonic energy. New claim 200 recites the method of claim 199 wherein the nanotubes are etched for 24 hours, further wherein the etching provides single wall carbon nanotubes having an average bundle length of 0.5 micrometers.

Support for new claims 199 and 200 can be found in the specification as filed. In particular, for example, support for new claim 199 can be found in the specification at page 9, lines 10-11. Support for new claim 200 can be found at page 9, lines 12-14.

For the reasons set forth hereinabove, claims 174-200 are believed to be patentable. Accordingly, allowance of claims 174-200 is respectfully requested.

## Other Claim Amendments

Claims 103, 118, 133, 150, and 162 have been amended herein to correct a typographical error. A decimal point has been inserted in the lower concentration limit recited in the claims. Support for the amendment can be found in original claim 17.

As described hereinabove with regard to claims 137 and 142, claims 107, 122, and 166 have been amended herein to clarify that the material being heated to the first and second temperatures is the same material (*i.e.*, the coated substrate). Applicants respectfully submit that this amended wording is in

keeping with the disclosure in the specification, which recites that the coated substrate can be heated to a temperature of approximately 100-1200°C for approximately 1 hour and then at approximately 800°C for two hours. See Specification, page 13, lines 4-6.

## CONCLUSION

In light of the above amendments and remarks, it is respectfully submitted that the present application is now in proper condition for allowance, and an early notice to such effect is earnestly solicited.

If any small matter should remain outstanding after the Patent Examiner has had an opportunity to review the above Remarks, the Patent Examiner is respectfully requested to telephone the undersigned patent attorney in order to resolve these matters and avoid the issuance of another Official Action.

## FEE DUE

A check in the amount of $3,120.00 is enclosed for the fee due. The Commissioner is authorized to charge any deficiencies of payment associated with the filing of this correspondence to Deposit Account No. **50-0426** to avoid the unintentional abandonment of the instant application.

Respectfully submitted,

JENKINS, WILSON, TAYLOR & HUNT, P.A.

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